S/OH-172109-65-63
Jet # 660207-00
PO # 534341

MODEL 132A

PULSE GENERATOR

SERIAL NOS. PREFIXED A

AUG 4 - 1965

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E-H RESEARCH LABORATORIES, INC.
163 ADELINE STREET · OAKLAND 20, CALIFORNIA

MODEL 132A

PULSE GENERATOR

SERIAL NOS. PREFIXED A

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EH RESEARCH LABORATORIES, INC.

163 ADELINE STREET • TEmplebar 4-3030 • OAKLAND 20, CALIFORNIA

Issue Date 2-8-65

SPECIFICATIONS

The E-H Model 132A Pulse Generator is designed to provide fast rise time, high current pulses over a broad range of pulse widths and repetition rates. It is suitable for a variety of applications including design problems involving magnetic materials, solid state research, high speed diode and transistor switching characteristics, and high current logic and memory circuits. It includes provisions for external driving or gating, provides a trigger for sync purposes, and an output attenuator.

REPETITION RATE - 5 cps to 3.5 megacycles internally selectable by a front panel step and vernier control. The instrument may be externally driven from zero to 3.5 megacycles by a negative 4-volt pulse.

RISE TIME - Positive Pulse: Typically 10 nanoseconds and less than 12 nanoseconds, variable to more than 100 nanoseconds. Negative Pulse: Typically 9 nanoseconds and less than 10 nanoseconds, variable to more than 100 nanoseconds.

FALL TIME - Typically 15 nanoseconds, 10 per cent to 90 per cent.

PULSE OUTPUT - 50 volts.

OUTPUT IMPEDANCE - 50 ohms.

PULSE WIDTH - Less than 100 nanoseconds to more than 10 milliseconds continuously variable by step and vernier controls.

PULSE DELAY - Less than 100 nanoseconds to more than 10 milliseconds continuously variable by step and vernier controls.

POLARITY - Positive or negative pulses selected on the front panel.

DUTY FACTOR - 25 per cent at full amplitude; 50 per cent at reduced amplitude. An automatic limiter prevents overload.

OUTPUT ATTENUATOR - Up to 150:1, coarse selector and continuous vernier control.

JITTER - Less than 0.1 per cent.

TRIGGER OUTPUT - For sync purposes, a 5-volt negative pulse approximately 50 nanoseconds wide is provided.

EXTERNAL DRIVE - A 4-volt ~~positive~~ negative pulse is required to externally drive the Model 132A.

ELECTRONIC GATE - 5 volts negative connected to the gate input will interrupt the pulse train for the duration of its presence. Input impedance is 2.4 K.

DIMENSIONS

Rack Mounted: 7" high, 19" wide, 16" deep.
Weight: 22 lbs. net; 30 lbs. packed; 42 lbs. packed for export.

ACCESSORIES

End frames are available for bench use. Price $35.

For short pulses, use the Model ZT Series Pulse Transformers to invert the output pulse or to match other impedances. Standard impedances are any permutation of 50, 93, 125, 185, or 200 ohms, normal or inverting. Coaxial body with BNC connectors. Price $35.

Use the Model RT Rise Time Integrators to obtain precise rise times in applications where responses to slow rise times are important. Standard rise times of 5, 10, 20, 50, and 100 nanoseconds; other values on special order. Price $35.

Use Model 921 Variable Delay Generator between an external driving source and a Model 132A to obtain precise pulse positioning; or between two or more Model 132A's. Continuously variable delays from 50 nanoseconds to 100 microseconds. Price $425.

The coarse DELAY selector and the FINE vernier provide continuous control over the relative position of the trigger output and pulse output. The pulse output can be delayed from .1 microsecond to 10 milliseconds with respect to trigger output.

The amplitude of the output pulse is continuously variable over an approximate 3:1 range by the AMPLITUDE control.

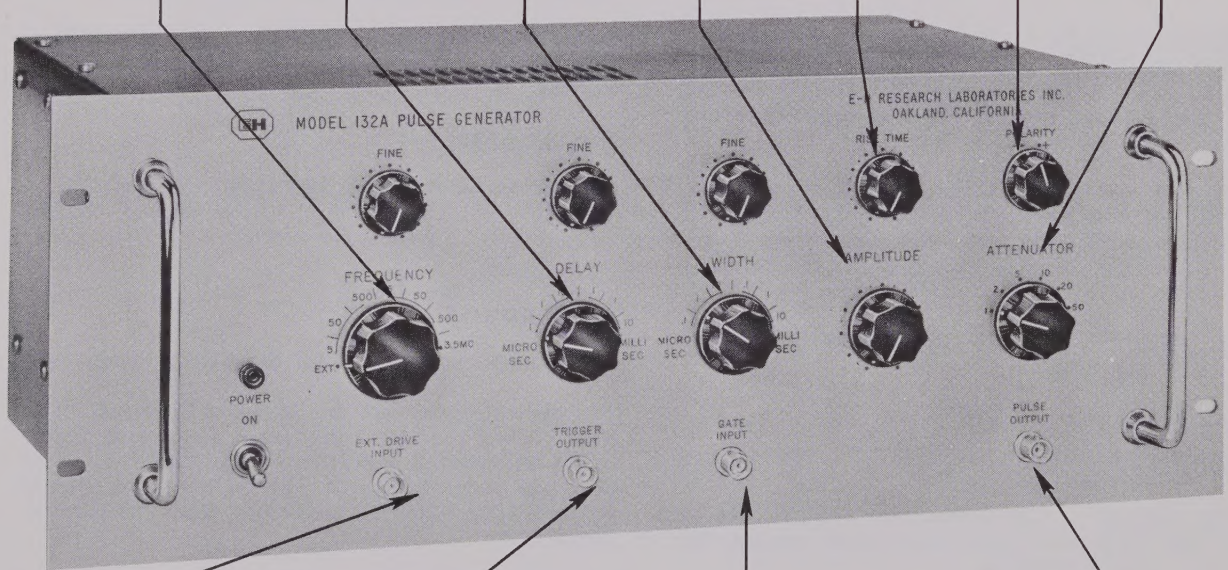
The POLARITY switch selects either positive or negative output pulses.

The internal rep. rate is controlled by a coarse FREQ. RANGE selector, which is calibrated in decade steps. The FINE control provides continuous coverage within the selected decade range.

The coarse WIDTH selector switch and FINE control vary the width of output pulses from .1 microsecond to 10 milliseconds.

The RISE TIME control varies the leading edge rise time from 10 to 100 nanoseconds.

The six step ATTENUATOR provides attenuation from 1:1 to 50:1.



To drive the instrument externally, FREQ. RANGE selector must be set to EXT. and 4-volt negative pulse applied to the EXT. DRIVE INPUT connector.

The trigger output is a negative 5-volt pulse.

A negative 5-volt signal applied to the GATE INPUT will interrupt the pulse train as long as the signal remains.

The pulse train is taken from the PULSE OUTPUT connector. The output is designed to operate into a 50-ohm, resistive load.

OPERATING INFORMATION

230—VOLT OPERATION

The internal power supply of the Model 132A is normally wired for 115-volt operation. Simple rewiring of the transformer primary permits operation at 230 volts. Refer to the schematic diagram at the back of this manual for the proper primary connection to provide operation at 230 volts.

CONTROLS

The operating controls, which are mounted on the front panel, and the instructions for their proper use are shown in the illustration on the opposite page.

OUTPUT IMPEDANCE

The Model 132A is a current source when the output pulse is negative and a voltage source when the output pulse is positive. Although the impedance at the output connector is not 50 ohms, the instrument is designed to operate into a 50-ohm resistive load. Operation into any other impedance will cause some pulse distortion. Loads with appreciable capacitive or inductive components will have a marked effect on the leading and falling edges of the pulse.

Use the Model ZT Pulse Transformer to match the Model 132A output to other impedances.

CAUTION

The instrument should always be operated with a load connected to the output.

DUTY CYCLE

The duty cycle limitation is to insure long life by conservative operation of the output tubes. The duty cycle is controlled electronically by monitoring the output current to maintain it at a maximum of 250 milliamps average. The effect is that as the duty cycle reaches 25 per cent, the amplitude of the output pulse is proportionately decreased as the duty cycle is increased.

NOTE

The minimum available pulse width and the duty cycle limitation prevent full output at 3.5 megacycles.

Typically, pulse widths of up to 80 per cent of the period can be obtained. Extending the pulse width past the normal period may cause the generator to scale down in frequency or unusual pulse distortion conditions to appear. However, no damage can occur to the instrument.

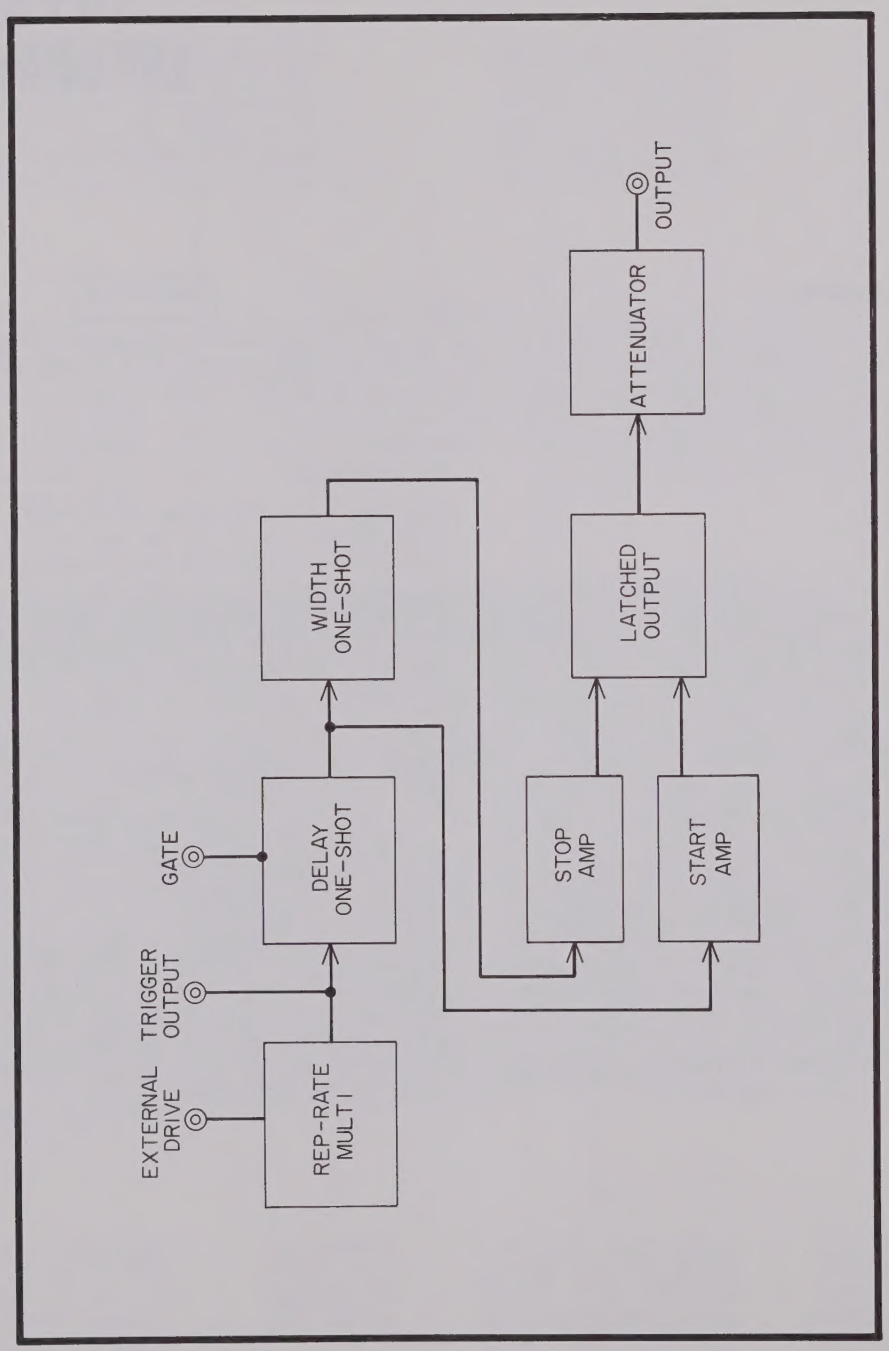


FIG. 1 BLOCK DIAGRAM, MODEL 132A

THEORY OF OPERATION

GENERAL DESCRIPTION

Refer to the block diagram on the opposite page. The basic timing cycle is initiated by a symmetric multivibrator, which may be free-running or externally driven. The output from the repetition rate multivibrator is differentiated, amplified, and applied to a gate circuit which passes a signal to the delay one-shot multivibrator unless a voltage is applied to the gate input, which then blocks the pulse train. The output of the amplifier is also coupled to the trigger output amplifier.

The delay one-shot multivibrator determines the position of the output pulse with respect to the trigger. The signal from the delay one-shot is amplified and goes to the width one-shot multivibrator which determines the width of the output pulse. The signal from the delay amplifier is also applied to the start amplifier to initiate the start of the output pulse.

The output from the width one-shot amplifier is applied to the stop amplifier to initiate the stop of the output pulse. The start and stop amplifiers drive the latch. The latch is a quasi-stable circuit which is turned on by the start signal and remains in that state, providing a constant amplitude output level, until turned off by the stop signal.

REPETITION RATE MULTIVIBRATOR

Q1 and Q2 comprise a free-running multivibrator capable of running at very fast repetition rates. To understand the operation of this multivibrator, assume that the switching is as shown on the schematic and that the timing capacitor has charged up to some positive level. Q1 is consequently turned off and Q2 is forced into conduction by the negative bias obtained through R3, CR3, and R9. The timing capacitor on the base of Q1 will discharge through variable resistor R2 and fixed resistor R8 to the negative voltage level at the base of Q2.

It is important to note that because Q2 is conducting, there is a voltage drop across R7 and, consequently, the emitter voltage of Q2 is less than the emitter voltage of Q1. Thus, the timing capacitor on the base of Q1 will discharge to the voltage level at the base of Q2 until such time as the base emitter drop of Q1 becomes less than the base emitter drop of Q2. Q1 will then start to conduct; its collector voltage will start to go positive, which in turn will cause the base of Q2 to go positive, forcing it out of conduction.

The timing capacitor now takes on the charge due to the difference in potentials between the bases. As the capacitor charges, Q1 remains in conduction until the difference in potential between the bases is slightly less than the bias developed across R4. When this occurs, Q2 is forced back into conduction and Q1 becomes cut-off.

AMPLIFIER AND GATE

Q3 is an amplifier to drive the delay multivibrator. In a condition without the presence of a gate signal, Q3 is nonconducting. The differentiated pulse from the multivibrator is amplified by Q3 when a gating signal is not present.

The gate amplifier Q4 is connected with its emitter in parallel with Q3. Q4 also is cut-off as determined by the biases of the diodes. When a negative 5-volt gating signal is applied to the base of Q4, the common emitters of Q3 and Q4 are held several volts negative. Q3, then, cannot conduct and the pulse chain is interrupted for as long as the gating signal is applied. Note that the zener diode protects the base of Q4 from being driven too far negative by large amplitude gating signals.

TRIGGER OUTPUT

The amplifier output is capacitively coupled to Q5. The trigger output amplifier Q5 produces a sharp negative trigger spike, approximately 5 volts in amplitude, which is delivered to the front panel through a capacitor.

DELAY MULTIVIBRATOR

The output of amplifier Q3 is applied directly to the delay multivibrator, comprised of Q6, Q7, and Q8. Q8 is a low impedance source for driving the timing capacitors, while Q6 and Q7 form a monostable

multivibrator. In the stable condition Q7 is biased on -- the bias being developed across the forward resistance of diode CR12. With Q7 on, Q6 is forced into nonconduction. The input of the multivibrator is the base of Q8. It is an emitter follower and whenever a positive input pulse is received from the previous stage, it is coupled through Q8 and one of the timing capacitors to the base of Q7. Q7, which is normally conducting, is cut-off by the positive swing and Q6 is forced into conduction. As Q6 goes into conduction, its collector goes positive. The collector of Q6 is tied to the base of Q8 so the action becomes regenerative, and the multivibrator very rapidly switches to its quasi-stable state until the timing capacitor is discharged through variable resistor R26 and fixed resistors R25 and R27. Variable resistor R26 controls the discharge time and serves as the FINE DELAY control. The output of the delay multivibrator is a small positive pulse taken from the collector of Q7 by differentiating through C38. This pulse drives Q13, the start pulse amplifier.

WIDTH MULTIVIBRATOR

The operation of the width amplifier Q9 and the width multivibrator Q10, Q11 and Q12 is identical to the delay multivibrator, except that the drive pulse to start the width multivibrator is taken from the start amplifier Q13 through capacitor C40 to the base of Q9.

START AND STOP AMPLIFIER

The start pulse amplifier Q13 is biased nonconducting by CR18. When the positive start pulse from the delay multivibrator arrives, it drives Q13 into conduction which provides a sharp current pulse through transformer T2. The operation of Q16 is identical except that it receives its pulse from the width multivibrator --therefore, initiating the stop pulse.

OUTPUT CIRCUITRY

The output pentode tube V1 is operated with approximately equal loads in the plate and cathode at all times. When the POLARITY switch is in the plus position, the attenuator presents its load to the cathode and R63-66 (a 40-ohm, 8-watt resistor) is in the plate circuit. When the POLARITY switch is in the negative position, the +175 volts is grounded and V_O becomes -175 volts; the 40 ohm resistance is switched to the cathode and the output is taken from the plate of V1.

The output circuitry will be described assuming the POLARITY switch is in the positive position. The output tube V1 and transistors Q14 and Q15 form a bi-stable latching-circuit, which when driven on will remain on until driven off. CR28 is a zener diode which holds the grid at -39 volts bias during the normally off condition so that no current flows in the output tube. The collector of transistor Q14 is also held at -39 volts. When the negative start pulse from T2 is received at the base of Q14, it turns that transistor fully on. As that transistor conducts, its collector rises. The grid of V1 also rises, turning on Q1. The cathode follows the grid producing the output pulse. Hold current to keep the transistor in saturation once it is turned on is provided through CR29, R84, R85, and R86. The -150 volt supply draws sufficient current through R85 and R86 from the base of Q14 to hold that transistor on.

Since the current through the zener diode also flows to the cathode and, therefore, through the load, resistors R57, R58 and R59 are inserted to bleed some positive current into the cathode load to offset this negative current so that there is no DC level shift.

The stop pulse from Q16 is coupled through transformer T1 to the base of Q15. The collector of Q15 is coupled through diode CR26 to the grid of V1 so that when the stop pulse appears, the grid of V1 is again driven negative to its -39 volt turn-off bias. The third winding on T1 also provides a positive pulse through CR22 and CR23 to the base of Q14, which helps turn off this transistor at the time of the stop pulse.

DUTY CYCLE LIMITING

The output pulse amplitude is controlled by the screen voltage of V1. At maximum amplitude, the screen is approximately 260 volts. Under this condition the cathode voltage is at maximum amplitude, about 50 volts, and the average current flowing is a function of the duty cycle. This current is monitored by R125 and averaged across capacitor C106 so that it appears as a voltage on the base of Q101. The collector of Q101 is connected directly to the grid of V104, which controls the grid voltage to V106. When this bias voltage reaches a point equivalent to 250 milliamps average current, Q101 conducts and pulls the screen of V106 down, thus reducing the screen supply and output amplitude proportionately.

POWER SUPPLY

The +175 volt supply is a conventional series regulated supply and is referenced to the gas tube V105. V101 and V102 are the series regulators being controlled by V103. This +175 volts is set by adjusting the grid voltage of V103 with R112.

The +175 volt supply is floating so that both polarity output pulses may be obtained. For positive pulses, V_O is grounded; for negative output pulses, the +175 volts is placed at ground.

The -150 volt supply is shunt regulated by V105, an OA2. The +50 to +270 volt supply, which is the screen supply and output amplitude control, is regulated by the series tube V106 and the reference tube V104. This voltage is adjusted by R128 which is the front panel AMPLITUDE control. The screen supply also is floating so that both polarity output pulses may be obtained.

The low voltage timing circuit supply is controlled by two series transistors Q105 and Q104. Amplifiers Q102 and Q103 are referenced to the zener diode CR111.

REVISIONS						
LTR	REVISION	DATE	DRAWN	CHK'D	APP'D	E. H.
A	ORIGINAL	8/15/65				
B	REVISED	3/67				
C	C108 was 100 μf/450V	4-26-68	CLK	BMF		

PROPRIETARY INFORMATION
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D-10679 C

TITLE: MODEL 132 POWER SUPPLY — D-10679 C — SHEET NO. ___ OF ___

115 VAC
F101 3A
S101 ON
DS1
R144 100K
BLK
RED/YEL
BLK/YEL
BLK/GRN
BLK/RED
FAN
T101
BLUE
RED
IN2071 CR101-102 30, 1W R101
C103 100 450V
IN2071 CR103 5, 10W R102
C101 250 300V
IN2071 CR104
C102 100 450V
IN2071 CR105-106 30, 1W R103 4K, 10W R104
BRN 6.3V
BRN
FILAMENTS
V101 6080
V102 6080
V103 6AU6
V104 6AU6
V105 0A2
V106 7119
V1 7534 RF. DECK
L9
R106 160K
R107 360K
R108 100
R109 22
R114 22
R115 100
R116 100
R117 22
R118 22
R119 100
R110 30K W
C104 .01 200V
R113 160K
R112 50K 175V ADJUST*
R105 62K
R111 150K
R120 100K
R121 2K 5%
R122 180 .22
R123 20K 2W
C105 .1
Q101 2N1309
C106 250 12V
R125 5.3W
R124 10K
R126 100K
V104 6AU6
V106 7119
C107 500pf
R127 160K
C108A 100 350V
R128 100K AMPLITUDE
R146 39K 2W
R129 150K
C108B 100 350V
RED SCREEN SUPPLY
BLU / WHT Vo
V10 / WHT -150V
+175V
GRAY

230 VAC
F102 1.5A
S101
R145 100K
DS1
BLK
GRN/YEL
BLK/YEL
BLK/GRN
BLK/RED
FAN
T101
GRN
IN2071 CR107 2.7, 1W R130
CR108
C109 4000 15V
C110 4000 15V
CR109
CR110
IN2071 CR131 2.7, 1W R131
R133 150
R132 .50 "+5.1V" ADJUST
R134 200
R135 510
C111 250 12V
IN753 CR111
R139 750
R140 510 1W
Q102 2N1306
R141 15
Q105 2N2250
C113 250 12V
R142 511 1%
GREEN +5.1V
VIOLET
C112 250 12V
Q103 2N1309
R136 510
R137 510
R138 510
Q104 2N2250
R143 475 1%
C114 250 12V
WHITE -5.1V

PRIMARY CONNECTION OF TRANSFORMER FOR 230 V AC

NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTANCES GIVEN IN OHMS
2. ALL RESISTORS ARE ±W, 5%
3. ALL CAPACITANCES GIVEN IN MICRO-FARAD

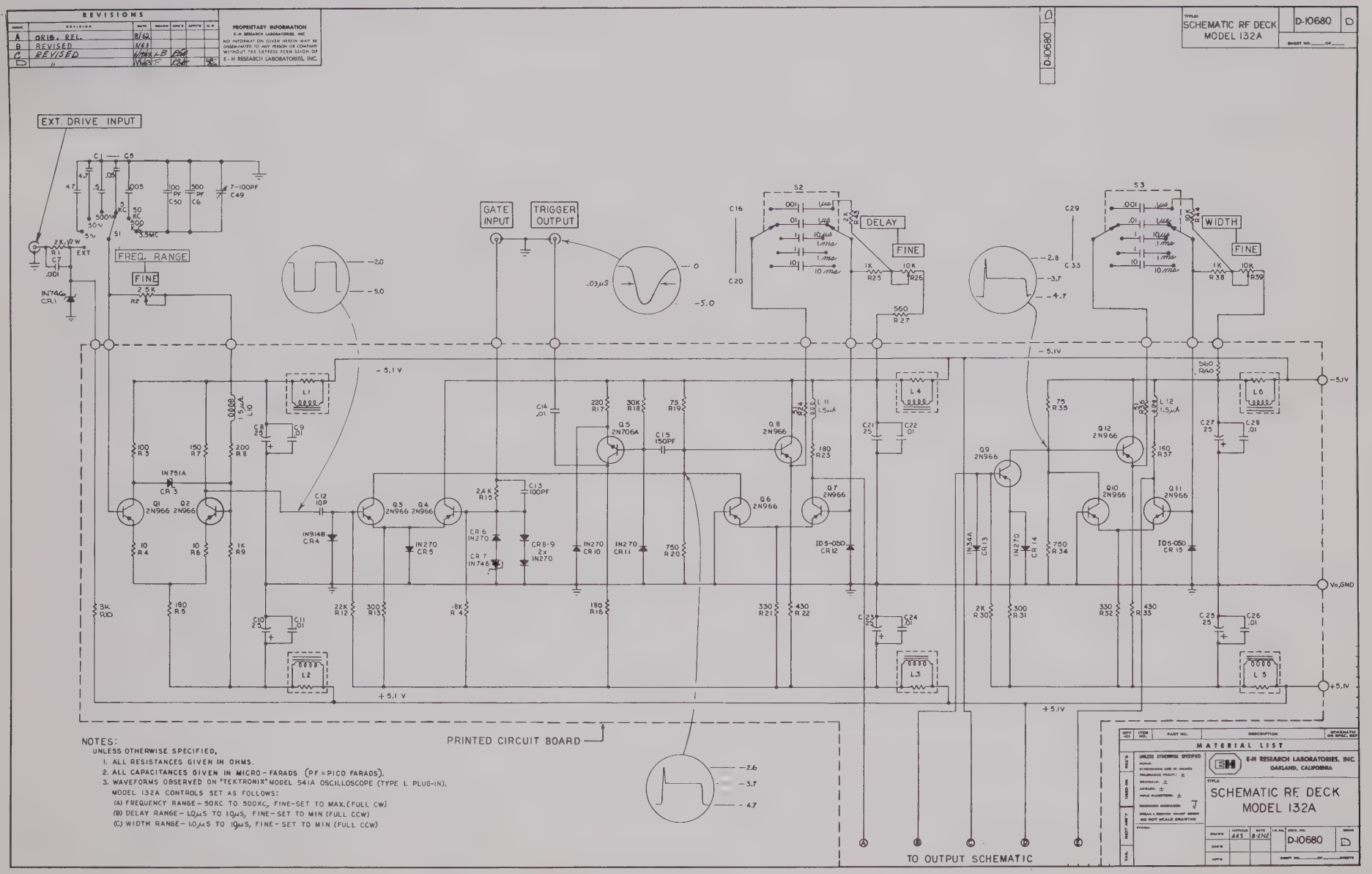
MATERIAL LIST

QTY	ITEM NO	PART NO	DESCRIPTION	SCHEMATIC OR SPEC. REF

E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

TITLE: MODEL 132 A POWER SUPPLY

DRAWN: LLS 8/15 — SIZE D — DWG NO. D 10679 — REV C
CHK'D: 8/15/68
APP'D
SHEET NO. ___ OF ___ SHEETS


REVISIONS
A ORIG. REL. 9/62
B REVISED 3/63
C REVISED 6/1963 LB
D " 11/1963
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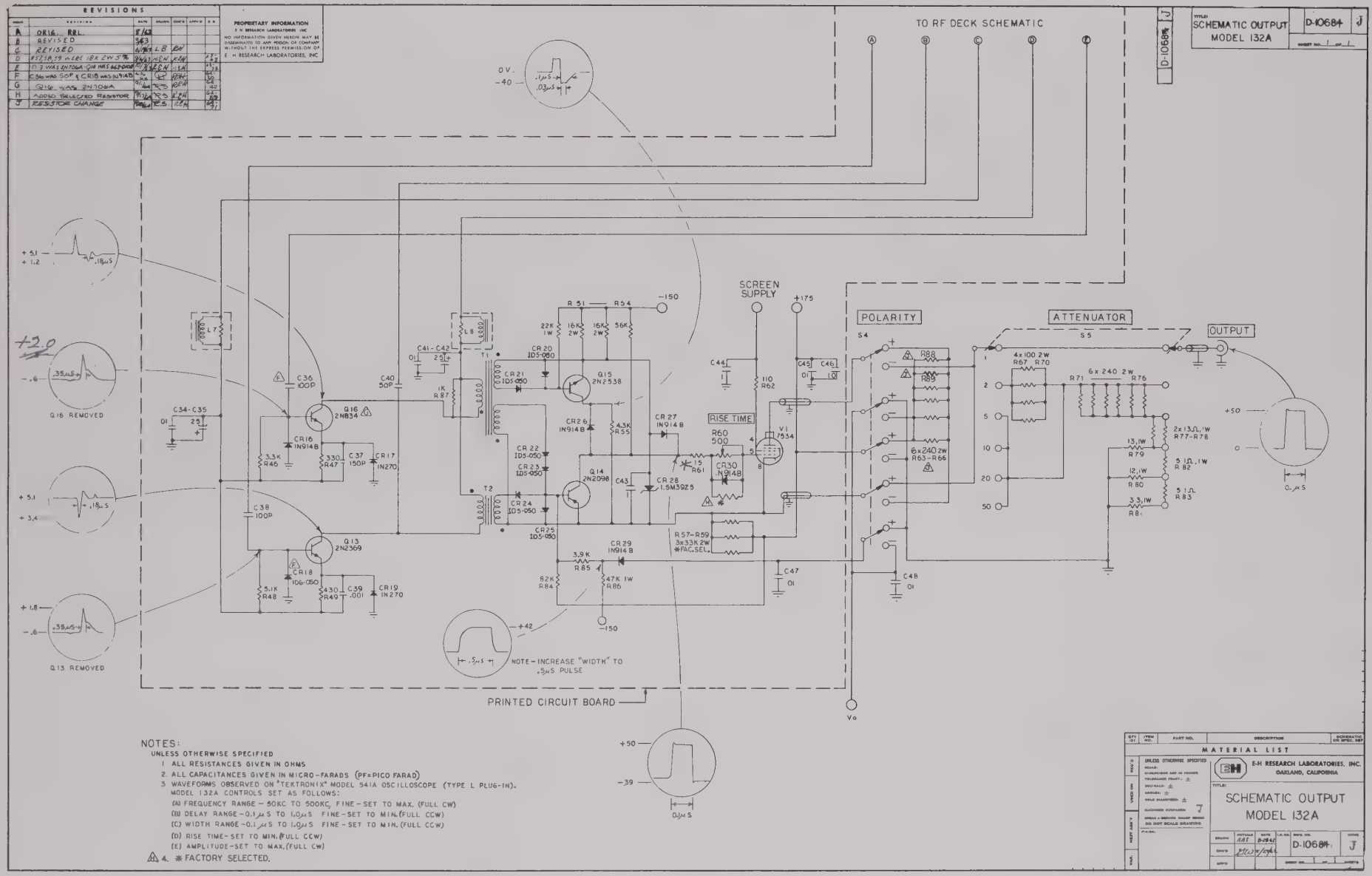
D-10680 D
TITLE: SCHEMATIC RF DECK MODEL 132A
D-10680 D
EXT. DRIVE INPUT
FREQ. RANGE
FINE
GATE INPUT
TRIGGER OUTPUT
DELAY
FINE
WIDTH
FINE
-5.1 V
+5.1 V
PRINTED CIRCUIT BOARD
TO OUTPUT SCHEMATIC
NOTES:
UNLESS OTHERWISE SPECIFIED,
1. ALL RESISTANCES GIVEN IN OHMS.
2. ALL CAPACITANCES GIVEN IN MICRO-FARADS (PF=PICO FARADS).
3. WAVEFORMS OBSERVED ON "TEKTRONIX" MODEL 541A OSCILLOSCOPE (TYPE L PLUG-IN).
MODEL 132A CONTROLS SET AS FOLLOWS:
(A) FREQUENCY RANGE - 50KC TO 500KC, FINE-SET TO MAX. (FULL CW)
(B) DELAY RANGE - 1.0μS TO 10mS, FINE - SET TO MIN (FULL CCW)
(C) WIDTH RANGE - 1.0μS TO 10mS, FINE - SET TO MIN (FULL CCW)
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
SCHEMATIC RF DECK MODEL 132A
D-10680 D


REVISIONS
PROPRIETARY INFORMATION
E H RESEARCH LABORATORIES, INC
TO RF DECK SCHEMATIC
D-10684 J
TITLE: SCHEMATIC OUTPUT MODEL 132A
D-10684 J
SCREEN SUPPLY
+175
-150
POLARITY
ATTENUATOR
OUTPUT
S4
S5
RISE TIME
PRINTED CIRCUIT BOARD
Vo
Q16 REMOVED
Q13 REMOVED
NOTE - INCREASE "WIDTH" TO .5μS PULSE
0.μS
0.1μS
NOTES:
UNLESS OTHERWISE SPECIFIED
1 ALL RESISTANCES GIVEN IN OHMS
2. ALL CAPACITANCES GIVEN IN MICRO-FARADS (PF=PICO FARAD)
3 WAVEFORMS OBSERVED ON "TEKTRONIX" MODEL 541A OSCILLOSCOPE (TYPE L PLUG-IN).
MODEL 132A CONTROLS SET AS FOLLOWS:
(A) FREQUENCY RANGE - 50KC TO 500KC, FINE - SET TO MAX. (FULL CW)
(B) DELAY RANGE - 0.1 μS TO 1.0μS FINE - SET TO MIN. (FULL CCW)
(C) WIDTH RANGE - 0.1 μS TO 1.0μS FINE - SET TO MIN. (FULL CCW)
(D) RISE TIME - SET TO MIN. (FULL CCW)
(E) AMPLITUDE - SET TO MAX. (FULL CW)
4. * FACTORY SELECTED.
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
SCHEMATIC OUTPUT MODEL 132A
D-10684 J

PARTS LIST

ORDERING INFORMATION

To insure your receiving the proper replacement part, please include the following information with your order.

1. Model Number and Serial Number of the instrument for which the replacement part is intended.
2. Circuit Reference of the part.
3. E-H Part Number.

Replacement parts may be ordered through your E-H Representative or from the factory.

WARRANTY

This instrument is guaranteed to be free from defects in material and workmanship. Our obligation is limited to repairing the instrument should it prove to be defective, upon our examination, within one (1) year after the purchase date. Fuses and batteries are specifically excluded from warranty. Electron tubes, transistors, and diodes are warranted for six (6) months.

For In-Warranty repair of this instrument contact E-H Research Laboratories, Customer Service Department, and provide:

1. Instrument Model Number and Serial Number
2. Full details of the nature of the malfunction

Shipping instructions, or repair information and parts, will be given you promptly.

CUSTOMER SERVICE DEPARTMENT, E-H RESEARCH LABORATORIES, INC.

163 ADELINE STREET, OAKLAND, CALIFORNIA - Phone: TE 4-3030, Area Code 415

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
C1	capacitor, fixed, electrolytic, 50 uf, 25 wvdc	316-037
C2	capacitor, fixed, electrolytic, 5 uf, 6 wvdc	316-011
C3	capacitor, fixed, metalized, mylar, .5 uf, ±5%, 200 v	320-009
C4	capacitor, fixed, metalized, mylar, .05 uf, ±5%, 200 v	320-005
C5	capacitor, fixed, polystyrene, .005 uf, ±5%, 500 v	326-004
C6	capacitor, fixed, polystyrene, 500 pf, ±5%, 500 v	326-003
C7	capacitor, fixed, polystyrene, .001 uf, ±5%, 500 v	326-005
C8	capacitor, fixed, electrolytic, 25 uf, 25 wvdc	316-028
C9	capacitor, fixed, ceramic, .01 uf, 600 v	311-012
C10	Same as C8.	
C11	Same as C9.	
C12	capacitor, fixed, ceramic, 10 pf, ±10%, 1 KV	311-001
C13	capacitor, fixed, ceramic, 100 pf, ±10%, 1 KV	311-007
C14	Same as C9.	
C15	capacitor, fixed, ceramic, 150 pf, ±10%, 1 KV	311-008
C16	Same as C7.	
C17	capacitor, fixed, polystyrene, .01 uf, ±5%, 500 v	326-006
C18	capacitor, fixed, metalized, mylar, .1 uf, ±5%, 200 v	320-007
C19	capacitor, fixed, metalized, mylar, 1 uf, ±5%, 200 v	320-011
C20	capacitor, fixed, electrolytic, 10 uf, 100 wvdc	316-032
C21	Same as C8.	
C22	Same as C9.	
C23	Same as C8.	
C24	Same as C9.	
C25	Same as C8.	
C26	Same as C9.	
C27	Same as C8.	
C28	Same as C9.	
C29	Same as C7.	
C30	Same as C17	
C31	Same as C18.	
C32	Same as C19.	
C33	Same as C20.	
C34	Same as C9.	
C35	Same as C8.	
C36	capacitor, fixed, ceramic, 50 pf, ±10%, 1 KV	311-006
C37	Same as C15.	
C38	Same as C13.	
C39	capacitor, fixed, ceramic, .001 uf, ±10%, 1 KV	311-010
C40	Same as C36.	
C41	Same as C9.	
C42	Same as C8.	
C43	capacitor, fixed, ceramic, .1 uf, +80-30%, 75 v	311-014
C44	capacitor, fixed, ceramic, .1 uf, +80-20%, 75 v	311-023
C45	Same as C9.	
C46	Same as C19.	
C47-48	Same as C9.	
C49	capacitor, variable, ceramic, 7-100 pf, 250 v	332-003
C101	capacitor, fixed, electrolytic, 250 uf, 300 wvdc	316-040
C102-103	capacitor, fixed, electrolytic, 100 uf, 450 wvdc	316-008
C104	Same as C19.	
C105	Same as C43.	
C106	capacitor, fixed, electrolytic, 250 uf, 12 wvdc	316-031
C107	Same as C6.	
C108	Same as C102.	
C109-110	capacitor, fixed, electrolytic, 4000 uf, 15 wvdc	316-003
C111-114	Same as C106.	
CR1	diode, zener, 1N746A, 400 mw, 3.3 v, ±5%	374-017
CR2	Not used.	
CR3	diode, zener, 1N751A, 400 mw, 5.1 v, ±5%	374-022
CR4	diode, 1N914B	376-022
CR5-6	diode, 1N270	376-031
CR7	Same as CR1.	
CR8-11	Same as CR5.	
CR12	diode, ID5-050	376-040
CR13	diode, 1N34A	376-023
CR14	Same as CR5.	
CR15	Same as CR12.	
CR16	diode, 1N914B	376-022
CR17	Same as CR5.	
CR18	Same as CR16.	
CR19	Same as CR5.	
CR20-25	Same as CR12.	
CR26-27	Same as CR16.	
CR28	diode, zener, 1.5 w, 39 v, ±10%	374-001
CR29-30	Same as CR16.	
CR101-110	diode, 1N2071	376-034
CR111	diode, zener, 1N753, 400 mw, 6.2 v, ±10%	374-019
T1	transformer, pulse	10660-01
T2	transformer, pulse	10661-01
T101	transformer, power	653-016

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
L1-8	inductor	10414-02
L9	inductor	10559-01
L10-12	inductor, fixed, 1.5 hf, ±10%	335-001
Q1-4	transistor, 2N966	663-032
Q5	transistor, 2N706B	663-023
Q6-12	Same as Q1.	
Q13	Same as Q5.	
Q14	transistor, E-H selected	663-010B
Q15	transistor, 2N2538	663-003
Q16	Same as Q5.	
Q101	transistor, 2N1309	663-021
Q102	transistor, 2N1306	663-018
Q103	Same as Q101.	
Q104-105	transistor, 2N250	663-026
V1	electron tube, 7534/E130L, pentode	670-026
V101-102	electron tube, 6080, twin triode	670-017
V103-104	electron tube, 6AU6, pentode	670-010
V105	electron tube, OA2, voltage regulator	670-007
V106	electron tube, 7119, twin triode	670-021
R2	potentiometer, comp, lin.taper, 2.5 K, 10%, 2 w	550-009
R26	potentiometer, comp, lin.taper, locking, 10 K, 10%, 2 w	545-006
R39	Same as R26.	
R51	resistor, fixed, composition, 22 K, 5%, 1 w	597-223
R52-53	resistor, fixed, composition, 16 k, 5%, 2 w	598-163
R57-59	resistor, fixed, composition, 33 K, 5%, 2 w, factory selected	598-333
R60	potentiometer, comp, lin.taper, 500 ohms, 30%, 1/2 w	550-029
R63-66	resistor, fixed, composition, 160 ohms, 5%, 2 w	598-161
R67-70	resistor, fixed, composition, 100 ohms, 5%, 2 w	598-101
R71-76	resistor, fixed, composition, 240 ohms, 5%, 2 w	598-241
R77-79	resistor, fixed, composition, 13 ohms, 5%, 1 w	597-130
R80	resistor, fixed, composition, 12 ohms, 5%, 1 w	597-120
R81	resistor, fixed, composition, 3.3 ohms, 5%, 1 w	597-033
R82	resistor, fixed, composition, 5.1 ohms, 5%, 1 w	597-051
R86	resistor, fixed, composition, 47 K, 5%, 1 w	597-473
R101	resistor, fixed, composition, 30 ohms, 5%, 1 w	597-300
R102	resistor, fixed, wirewound, 5 ohms, 5%, 10 w	610-017
R103	Same as R101.	
R104	resistor, fixed, wirewound, 4 K, 5%, 10 w	610-020
R110	resistor, fixed, composition, 30 K, 5%, 1 w	597-303
R112	potentiometer, comp., linear taper, locking, 50K, 10%, 2 w	545-008
R123	resistor, fixed, composition, 20 K, 5%, 2 w	598-203
R125	resistor, fixed, wirewound, 5 ohms, 5%, 3 w	610-003
R128	potentiometer, comp., linear taper, 100 K, 10%, 2 w	550-006
R130-131	resistor, fixed, composition, 2.7 ohms, 5%, 1 w	597-272
R134	potentiometer, miniature, multi-turn, lin.taper, 200 ohm, 2w, 10%	551-001
R142	resistor, fixed, carbon film, 511 ohms 1%, 1/2 w	601-062
R143	resistor, fixed, carbon film, 475 ohms, 1%, 1/2 w	601-061
R146	resistor, fixed, composition, 39 K, 5%, 2 w	598-393
NOTE:	All resistors on the schematic, which are not shown on this list, are 1/2 watt, ±5%, fixed, carbon composition.	
	Connector, power, 3-prong, chassis receptacle	700-018
	Fan blade, 4" counterclockwise	493-002
	Fan motor	543-001
F101	Fuse, 3 amp, slo-blo	398-003
F102	Fuse, 1.5 amp, slo-blo	398-013
	Fuse extractor post	396-001
DS1	Pilot light assembly, neon, red	510-008
	Power cable, 3-prong	786-001
S101	Switch, toggle, DPST	630-006

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